

**What is Claimed:**

1. A mass transfer system comprising:
  - (a) a housing for carrying a first fluid and defining a first fluid flow path; and
  - (b) at least one selectively fluid-permeable element defining a second fluid path, said element adapted to move relative to the flow of said first fluid, the selectively fluid-permeable element carrying a second fluid, which second fluid may pass through said selectively fluid-permeable element and thereby contact said first fluid within the first fluid path, resulting in a fluid exchange between the first and second fluids as the first fluid flows through the housing.
2. The mass transfer and pump apparatus of Claim 1, further comprising an agitator for moving the at least one selectively fluid-permeable element relative to the housing.
3. The mass transfer and pump apparatus of Claim 2, wherein the selectively fluid-permeable element is oriented substantially perpendicular to the bulk flow of the first fluid.
4. The mass transfer and pump apparatus of Claim 1, wherein said selectively fluid-permeable element is in fluid connection with a distributor element, and said distributor element comprises:
  - (a) a shaft defining a fluid inlet path and a fluid exit path;
  - (b) an inner ring;
  - (c) an outer ring concentrically spaced with respect to the inner ring such that the inner ring and the outer ring define a gas supply plenum and a gas return plenum;
  - (d) a fluid supply spoke having a inlet end in fluid communication with the fluid inlet path and a outlet end in fluid communication with the gas supply plenum; and
  - (e) a fluid return spoke having an outlet end in fluid communication with the fluid exit path and an inlet end in fluid communication with the gas return plenum.
5. The mass transfer and pump apparatus of Claim 4, wherein the selectively fluid-permeable element is positioned between the inner ring and the outer ring.
6. The mass 'transfer and pump apparatus of Claim 4, wherein said distributor element includes a plurality of selectively fluid-permeable membrane elements.
7. The mass transfer and pump apparatus of Claim 6, wherein the plurality of selectively fluid-permeable membrane elements are positioned m at least two layers, the elements of one layer being positioned non-parallel relative to elements in the other layer.
8. The mass transfer and pump apparatus of Claim 6, wherein each of the selectively fluid-permeable membrane elements are permeable to gas and impermeable to liquid.
9. The mass transfer and pump apparatus of Claim 1, further comprising a heat exchanger to alter the temperature of one of the first fluid and the second fluid.

10. The mass transfer and pump apparatus of Claim 9, wherein the heat exchanger is a fluid impermeable member defining a fluid path for a third fluid, the fluid impermeable member in fluid communication with the one distributor element.

11. The mass transfer and pump apparatus of Claim 4, wherein the distributor element comprises:

- (a) a shaft defining a fluid inlet path, a fluid exit path, a gas inlet path and a gas exit path;
- (b) an inner ring having a first face and a second face, the inner ring defining a circular opening;
- (c) an outer ring concentrically spaced with respect to the inner ring
- (d) a plurality of dividers extending between the outer ring and the inner ring such that a heat exchange fluid supply plenum, a fluid heat exchange return plenum, a gas supply plenum and a gas return plenum are defined by the inner ring, the outer ring and the plurality of dividers;
- (e) a fluid supply spoke having a inlet end in fluid communication with the fluid inlet path and a outlet end in fluid communication with the fluid supply plenum;
- (f) a fluid return spoke having an outlet end in fluid communication with the fluid, exit path and a inlet end in fluid communication with the fluid return plenum;
- (g) a gas supply spoke having a inlet end in fluid communication with the gas inlet path and a outlet end in fluid communication with the gas supply plenum;
- (h) a gas return spoke having an outlet end in fluid communication with the gas outlet path and a inlet end in fluid communication with the gas return plenum;
- (i) a plurality of fluid-impermeable membrane elements extending across the circular opening of the inner ring and between the inner ring and the outer ring, the plurality of fluid-impermeable membrane elements being in fluid communication with the fluid supply plenum and the fluid return plenum; and

wherein the plurality of selectively fluid-permeable membrane elements are in fluid communication with the gas supply plenum and the gas return plenum.

12. A pumping apparatus comprising:

- (a) a housing defining a fluid flow path;
- (b) at least one rotor mounted within the housing and adapted to move relative to the housing;

- (c) a plurality of selectively fluid-permeable membrane elements attached to the at least one rotor;
- (e) an actuator for agitating the at least one rotor such that a first fluid is pumped through the housing by the movement of the at least one rotor and the plurality of selectively fluid-permeable membrane elements.

13. The pumping apparatus of Claim 12, wherein the at least one rotor comprises:

- (a) a rotor shaft; and
- (b) a ring member defining a space and wherein the rotor shaft extends within the space and the plurality of membranes are attached to and radiate from the shaft to the ring member.

14. The pumping apparatus of Claim 13, wherein the rotor shaft extends parallel to the bulk flow of the fluid and the plurality of membranes are substantially perpendicular to the bulk fluid flow.

15. A heat exchanger comprising:

- (a) a shaft defining at least a fluid inlet path and a fluid exit path;
- (b) an inner ring;
- (c) an outer ring concentrically spaced with respect to the inner ring such that the inner ring and the outer ring define a fluid supply plenum and a fluid return plenum;
- (d) a fluid supply spoke having an inlet end in fluid communication with the fluid inlet path and an outlet end in fluid communication with the fluid supply plenum; and
- (e) a fluid return spoke having an outlet end in fluid communication with the fluid exit path and an inlet end in fluid communication with the fluid return plenum.

16. A blood pump-oxygenator comprising:

- (a) a housing defining a blood flow path and having a venous blood inlet, an arterial blood outlet, an oxygen inlet and an oxygen outlet;
- (b) a double lumen shaft defining a gas inlet path and a gas outlet path; wherein the double lumen shaft gas inlet path is in fluid communication with the housing gas inlet and the double lumen shaft gas outlet is in fluid communication with the housing gas outlet; and
- (c) at least one distributor element past which blood may flow, mounted on the double lumen shaft, the at least one distributor element having:
  - (i) an inner ring with a first face and a second face;

- (ii) an outer ring concentrically spaced with respect to the inner ring such that the inner ring and the outer ring define an oxygen supply plenum and an oxygen return plenum;
- (iii) a first hollow spoke in fluid communication with the oxygen inlet path and the oxygen supply plenum;
- (vi) a second hollow spoke in fluid communication with the oxygen outlet path and the oxygen return plenum; and

(vii) a plurality of selectively fluid-permeable membrane elements extending across the distributor disk blood flow path, each of the selectively fluid-permeable membrane elements in fluid communication with the oxygen supply plenum and the oxygen return plenum; and wherein when blood flows through the housing flow path and oxygen flows through and diffuses across the plurality of selectively fluid-permeable membrane elements and when the at least one distributor element rotates about the at least one double lumen shaft oxygenation/ decarbonation of blood and simultaneous pumping of blood occurs.

17. A method for mass transfer and pumping of fluids comprising:

- (a) transporting a first fluid into a housing defining a first fluid flow path;
- and
- (b) agitating at least one distributor element within the housing, wherein the one: distributor element has a plurality of selectively fluid-permeable membrane elements attached thereto and each of the plurality of selectively fluid-permeable membrane elements define a second fluid path, wherein when the at least one distributor element is agitated relative to the housing, the plurality of selectively fluid-permeable membrane elements carrying a second fluid contact a first fluid within the first fluid path resulting in a fluid exchange between the first and second fluids and the first fluid being simultaneously pumped through the housing;

18. A mass transfer apparatus comprising:

- (a) a housing defining a first fluid path;
- (b) at least one distributor element within the housing and adapted for movement relative to the housing; and
- (c) a plurality of selectively fluid-permeable membrane elements each defining a second fluid path and attached to the at least one distributor element, wherein when the at least one distributor element moves relative to the housing, the plurality of selectively fluid-permeable membrane elements carrying a second fluid contact a first fluid within the first fluid path resulting in a fluid exchange between the first and second fluids.

19. A method of oxygenating the blood of a patient comprising:

- (a) providing a mass transfer and pump apparatus having a housing defining a first fluid path; at least one distributor element within the housing; and a plurality of selectively fluid-permeable membrane elements each defining a second fluid path and attached to the at least one distributor element;
- (b) providing oxygen flow within the second fluid path;
- (c) directing the patient's venous blood past the external surface of the selectively fluid-permeable membrane elements while agitating the at least one distributor element such that when the at least one distributor element moves relative to the housing, the plurality of selectively fluid-permeable membrane elements carrying the oxygen contact the venous blood flowing within the first fluid path resulting in a fluid exchange between the venous blood and oxygen and the venous blood being simultaneously pumped through the housing, and
- (d) recovering blood that has been oxygenated and decarbonated from an arterial blood outlet of the housing for return to the patient.

20. An apparatus for hemodialysis comprising:

- (a) a housing defining a blood flow path and having a blood inlet, a blood outlet, a dialysis fluid inlet and a dialysis fluid outlet;
- (b) fluid outlet path wherein the double lumen shaft dialysis fluid inlet path is in fluid communication with the housing dialysis fluid inlet and the double lumen shaft dialysis fluid outlet is in fluid communication with the housing dialysis fluid outlet;
- (c) at least one distributor element mounted on the double lumen shaft and defining a blood flow path, the at least one distributor element having:
  - (i) an outer ring with a first and second face;
  - (ii) an outer ring cap concentrically spaced with respect to the outer ring such that the outer ring and outer ring cap define an dialysis fluid supply plenum and an dialysis fluid return plenum,
  - (iii) a first hollow spoke in fluid communication with the dialysis fluid inlet path and the dialysis fluid supply plenum.
  - (iv) a second hollow spoke in fluid communication with the dialysis fluid path and the dialysis fluid return plenum; and
  - (v) a plurality of selectively semi-permeable membrane elements extending across the distributor disk blood path and each of the plurality of selectively permeable membrane elements in fluid communication with the dialysis fluid supply plenum and the dialysis fluid return plenum; and wherein when blood flows through the housing flow path and the dialysate flows through the plurality of selectively fluid permeable membrane elements and when the at least one distributor element rotates about the at least one double lumen shaft, metabolic waste products from the blood diffuse into the dialysate which simultaneous heating and pumping of the blood occurs.

21. A method for dialyzing the blood of a patient, comprising the steps of:
- (a) providing a hemodialysis apparatus according to claim 20;
  - (b) providing a flow of dialysis fluid between the dialysis fluid inlet and dialysis fluid outlet;
  - (c) directing the patient's blood to the blood inlet of the hemodialysis apparatus and recovering blood from which metabolic waste products have been removed at the blood outlet for return to the patient.
22. An apparatus for liver assist comprising:
- (a) a housing defining a blood flow path and having a blood inlet, a blood outlet, a liver-assist fluid inlet and a liver-assist fluid outlet;
  - (b) a double lumen shaft defining a liver-assist fluid inlet path and a liver-assist fluid outlet path wherein the double lumen shaft liver-assist fluid inlet path is in fluid communication with the housing liver-assist fluid inlet and the double lumen shaft liver-assist fluid outlet is in fluid communication with the housing liver-assist fluid outlet;
  - (c) at least one distributor element mounted on the double lumen shaft and defining a blood flow path, the at least one distributor element having:
    - (i) an outer ring with a first and second face;
    - (ii) an outer ring cap concentrically spaced with respect to the outer ring such that the outer ring and outer ring cap define a liver-assist fluid supply plenum and a liver-assist fluid return plenum;
    - (iii) a first hollow spoke in fluid communication with the liver-assist fluid inlet path and the liver-assist fluid supply plenum;
    - (iv) a second hollow spoke in fluid communication with the liver-assist fluid path and the liver-assist fluid return plenum; and
    - (v) a plurality of selectively semi-permeable membrane elements extending across the distributor disk blood path and each of the plurality of selectively permeable membrane elements in fluid communication with the liver-assist fluid supply plenum and the liver-assist fluid return plenum; and wherein when blood flows through the housing flow path and the dialysate flows through the plurality of selectively fluid permeable membrane elements and when the at least one distributor element rotates about the at least one double lumen shaft, metabolic waste products from the blood diffuse into the dialysate which simultaneous heating and pumping of the blood occurs.